Annual Report 2012-13

Southwest Climate Science Center

ERICA FLEISHMAN

Contents

Providing natural and cultural resource managers with scientific information, tools, and techniques to anticipate, monitor, and adapt to climate change.


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Introduction

Now in its third year of operation, the Southwest Climate Science Center achieved several key milestones in 2012-2013, including welcoming its federal director, drafting long-term and annual science plans, and completing a third competitive research award process. **Projects funded in the first year of the Center's existence (2011) have so far yielded five peer-reviewed publications, one report directly to a stakeholder resource management agency, and significant contributions to a web portal for information about climate change in the Los Angeles region aimed specifically at a public audience.**

In addition to the activities of the Center as a whole, the principal and affiliate investigators, along with their graduate students, postdoctoral researchers, and research affiliates, have been productive in both their science and outreach efforts. **SW CSC investigators authored or co-authored 13 peer-reviewed publications** related to their work with the Center (see page 13). They presented their research results or information about the SW CSC at **14 different conferences** (see page 14). And investigators have reached out directly to the public and key stakeholders at numerous workshops and meetings (see pages 16-17). One of the most significant scientific and management contributions of the SW CSC investigators this year was the release of the ***Assessment of Climate Change in the Southwest,*** a book based on the region's contribution to the National Climate Assessment report (see page 18). **SW CSC investigators were authors on eight of the chapters**, including the Summary for Decision Makers, which is targeted specifically at resource and municipal managers in the region.

Early-career researchers in the Center have also had a productive year, authoring or co-authoring four peer-reviewed publications, presenting at national and regional conferences, and interacting regularly with SW CSC stakeholder groups (see page 19).

RETTA BRUEGGER

Milestones

NEW DIRECTOR

In September 2012, the SW CSC welcomed its new permanent federal director, Dr. Stephen Jackson. Dr. Jackson came to the SW CSC from the University of Wyoming, where he was a professor of botany and founding director of the doctoral program in ecology.

Before joining the University of Wyoming in 1995, Dr. Jackson held faculty positions at Indiana University, Idaho State University, and Northern Arizona University. He is past president of the American Quaternary Association and is on the governing board of the Ecological Society of America and the editorial boards of *Ecosystems, Frontiers in Ecology & Environment, and Trends in Ecology and Evolution*. His own research employs tree rings, fossil rodent middens, and sediments from lakes and bogs to investigate how past climatic changes and human activities have affected species distributions, biodiversity, and ecosystem properties.

Dr. Jackson received his Ph.D. in ecology and evolutionary biology from Indiana University and his B.A. and M.S. in botany and geology from Southern Illinois University at Carbondale.

In addition to his SW CSC directorship position through USGS, Dr. Jackson also holds two appointments at the University of Arizona: adjunct professor in the Department of Geosciences and adjunct research professor in the School of Natural Resources and the Environment.

STRATEGIC SCIENCE AGENDA

The SW CSC finalized its Strategic Science Agenda in December 2012. The Strategic Science Agenda identifies the region's key climate-science needs and the SW CSC's mission and goals, communication strategies, scientific priorities, and needed expertise for the next three to five years. The Science Agenda and Annual Workplan (see below) were written by Director Jackson and Acting Assistant Director James Leenhouts, after consultation with the Stakeholder Advisory Committee.

The Science Agenda lays out the vision for the Southwest Climate Science Center, which is to foster effective collaboration between scientists and resource managers in anticipating, monitoring, and adapting to climate variability and change in the Southwest, and to attain national distinction in developing best practices for translational climate science.

The Agenda outlines the guiding principles of the SW CSC.

- **Focus on management outcomes and solutions**
- **Co-production of knowledge by stakeholders and scientists**
- **Coordination of the different calendars of decision-making and research**
- **Clear communication of scientific capacities and uncertainties**
- **Utilization of experiential and local knowledge**
- **Commitment to span professional and disciplinary boundaries**
- **Development and application of metrics for gauging success**

Adherence to these principles requires trust, commitment, and engagement among all parties, including a willingness to transcend individual comfort zones. The SW CSC is committed to building communities of practice that integrate scientific knowledge with management concerns.

THE AGENDA IS AVAILABLE ONLINE AT: **DOI.GOV/CSC/SOUTHWEST/INDEX.CFM**

2013 ANNUAL SCIENCE PLAN

The Annual Science Workplan was also finalized in early 2013. The Workplan details the specific research priorities and planned actions for the SW CSC during federal fiscal year 2013.

For 2013, the SW CSC identified six research priorities, and constructed requests for proposals in order to attract research to address these key areas. These priority areas emerged from discussions with the Stakeholder Advisory Committee, discussions with Landscape Conservation Cooperative coordinators in the region, and through a stakeholder needs assessment review conducted by Christine Albano, Research Associate, and Alison Meadow, Program Manager, in Spring 2012.

1. **Anticipating climate change and variability at intermediate scales**
2. **Linking climatic, hydrological and ecological changes at intermediate scales**
3. **Hydrological effects of climate change in the Southwest**
4. **Effects of climate change on coastlines, estuaries, and wetlands**
5. **Design and implementation of monitoring strategies**
6. **Hydroclimatic change and terrestrial ecosystems**

THE 2013 WORKPLAN IS AVAILABLE ONLINE AT: **DOI.GOV/CSC/SOUTHWEST/INDEX.CFM**


BENJAMIN BLONDER

Funded Research

RESULTS FROM 2011 PROJECTS

In 2011, the first year the Southwest Climate Science Center funded new research, several of the principal investigators launched a collaborative project to evaluate the consistency of downscaled Intergovernmental Panel on Climate Change Assessment Report 5 (AR5) climate model projections when compared to the previous AR4 projections for specific subregions and seasons. The objectives of the project were to (a) archive the relevant AR5 model output data for the southwest region; (b) downscale daily temperature and precipitation to 12 X 12 km cell spatial resolution over the Southwest; (c) assess the precision (degree of agreement) of the simulated models; (d) assess the direction and magnitude of change in projections between AR4 and AR5, as well as assess projections of key extreme climatic events such as extreme drought, extreme seasonal precipitation, and extreme high and low temperature events; and (e) assess critical ecosystem impacts such as climate water deficit and fire, hydrological condition of major river systems, and impacts on highly valued species. In order to most efficiently accomplish these objectives, the investigators split the project into three focus areas. Summaries of each focus area are below.

Climate Change and its Impact on Ecological and Social Systems in the Southwest

PI: Mark Schwartz, University of California Davis

With: Amber Wright, Robert Hijmans, Betsy Bolster, H. Bradley Shaffer, and Alexander Gershunov

Our understanding of the complex interplay of factors that affect global climate, and our ability to accurately predict future climate, is constantly improving. It is important for the end-users of climate models, such as biologists and resource managers, to periodically update predictions of how species will respond to climate change so that conservation, mitigation, and adaptation strategies are based on the best available climate science. The Intergovernmental Panel on Climate Change Fourth Assessment Report (AR4, 2007) used a set of emissions scenarios to describe plausible future climate conditions. The forthcoming Fifth Assessment Report (AR5) replaces the scenarios with Representative Concentration Pathways that capture different future greenhouse gas concentrations. Most conservation assessments to date have been conducted with AR4 climate data, which have been readily available online for several years. We downscaled AR5 climate data for this project in

order to produce up-to-date conservation planning products and compare predictions made for species response under AR4 and AR5. We built ecological niche models to predict the distribution of climatically suitable habitat for 153 species of reptiles and amphibians in California. We then projected these models onto future climates predicted by seven general circulation models for the A2 emissions scenario for the AR4 data and RCP 8.5 for the AR5 data. We assessed conservation risk by ranking species by the percentage of habitat area predicted to no longer remain suitable in 2050. Preliminary analyses show that conservation risk is on average lower under AR5. We are currently in the process of determining what factors may be driving this result.

Results from this project have been shared with resource managers in California and Nevada through both a report to the California Department of Fish and Wildlife[1] and a presentation by the research team at the California-Nevada Amphibian Population Task Force Meeting in January 2013.

Climate Change in the Los Angeles Region: temperature and precipitation

PI: Alex Hall, UCLA

With: Daniel Walton, Neil Berg, and Ruth Cerezo-Mota

This project's central goal was to examine how temperature and precipitation could change by the mid 21st century over the greater Los Angeles region. Major findings for temperature are: (1) large variability in the magnitude exists among downscaled global climate model projections over LA, but all predict warming; (2) warming is smaller over the ocean and coastal zone, but larger in the mountain areas and inland; (3) ensemble-mean warming in all parts of the domain is significantly outside the range of historical variability, meaning the change will be detectable. Major findings for precipitation are: (1) large variability in both sign and magnitude exists among downscaled global climate model precipitation projections over LA; (2) the model-averaged change in precipitation is approximately zero; (3) the uncertainty in (1) is within the range of current (1981-2000) levels of interannual precipitation variability.

The investigators have used several approaches to communicate the findings from their research. They have integrated these new results into the website **c-change.la**, which allows stakeholders and the general public to access information about how climate change is likely to affect the Los Angeles region. They have given several talks to stakeholder groups in the region, including an Oppenheim Lecture at UCLA's Institute of Environment and Sustainability and at UCLA's Emmett Center on Climate Change and the Environment. Daniel Walton, a graduate student working on the project, and Alex Hall, the PI, spoke at the Echo Park United Methodist Church in March 2013 about the impacts of climate change in the Los Angeles region. The audience was largely made up of members of the faith community and other interested LA residents. Finally, two peer-reviewed publications are in preparation by the research team.

Comparison of climate models used in the IPCC Assessment Reports Four (AR4) and Five (AR5) for the Southwest U.S.

PI: Dan Cayan, Scripps Institution of Oceanography and USGS

With: Suraj Polade, Michael Dettinger, Alexander Gershunov, David Pierce, Mary Tyree

This project was aimed at comparing projected impacts between AR4 model projections and AR5 model projections. This understanding is necessary to assess the degree to which scientists should focus research energy recalculating already projected impacts versus moving forward to project impacts on resources that have not yet been assessed. The work accomplished under this funding

1 **Wright, AN**, Hijmans, RJ, **Schwartz, MW**, and HB Shaffer. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Draft report to the California Department of Fish and Wildlife, July 2013

has been important in gaining a better understanding of the AR5 simulations and how they project climate changes over the U.S. Southwest. This effort was an essential underpinning of ongoing work to diagnose and understand impacts of climate change over this region.

Five peer-reviewed publications have come from this project, including one led by SW CSC postdoctoral researcher Suraj Polade.

DeFlorio, M. J., D. W. Pierce, D. R. Cayan and A. J. Miller (2013). "Western U.S. Extreme Precipitation Events and Their Relation to ENSO and PDO in CCSM4." Journal of Climate 26(12): 4231-4243.

Pierce, D. W. and D. R. Cayan (2013). "The Uneven Response of Different Snow Measures to Human-Induced Climate Warming." Journal of Climate 26(12): 4148-4167.

Pierce, D., T. Das, D. Cayan, E. Maurer, N. Miller, Y. Bao, M. Kanamitsu, K. Yoshimura, M. Snyder, L. Sloan, G. Franco and M. Tyree (2013). "Probabilistic estimates of future changes in California temperature and precipitation using statistical and dynamical downscaling." Climate Dynamics 40(3-4): 839-856.

Pierce, D. W., D. R. Cayan, T. Das, E. P. Maurer, N. L. Miller, Y. Bao, Kanamitsu, K. Yoshimura, M. A. Snyder, L. C. Sloan, G. Franco, and M. Tyree (in press). "The key role of heavy precipitation events in climate model disagreements of future annual precipitation changes in California." Journal of Climate.

Polade, S. D., A. Gershunov, D. R. Cayan, M. D. Dettinger and D. W. Pierce (2013). "Natural climate variability and teleconnections to precipitation over the Pacific-North American region in CMIP3 and CMIP5 models." Geophysical Research Letters 40(10): 2296-2301.

The researchers also presented their findings to National Park Service staff, a key stakeholder group, in a presentation focused on projected temperature and precipitation changes from climate model simulations in the region of Channel Islands National Park at UC Santa Barbara in March 2012.

PROJECTS FUNDED IN 2012

In fiscal year 2012, the SW CSC funded seven new projects. Annual reports for these projects are expected in late 2013 and summaries will be available on our website(s) soon after.

Comparative analysis of downscaled climate simulations: Providing guidance to end-users

PI: Daniel Cayan, Scripps Institution of Oceanography

With: Bridget Thrasher, Alex Hall, and Michael Dettinger

Guidance for potential users of a large set of statistical downscaled simulations will be provided. The foundation for this guidance will be based upon a set of comparative analyses to better understand the accuracy and properties of statistical downscaled climate simulations and climate change projections.

Climate change vulnerability of Native Americans in the Southwest

PI: Karletta Chief, University of Arizona

With: Aleix Serrat-Capdevila, William J. Smith, David Busch

Native Americans in the Southwest are vulnerable to climate change because of their intimate relationship with the environment upon which their culture, tradition, and livelihood depend. Climate change may overwhelm tribes already stressed by economical and development challenges. A primary example is Nevada's largest tribe, Pyramid Lake Paiute Tribe, located at the terminal end

of the Truckee-Carson River, who are deeply connected—culturally, physically, and spiritually—to Pyramid Lake and its ecosystem. The objectives of this project are to: 1) determine the potential of the Pyramid Lake Paiute Tribe for adaption to climate change by understanding vulnerabilities, thresholds, and resiliencies of the systems; 2) develop collaborative tribal water management and adaptive strategies; and 3) produce a framework for a decision support system model of a coupled climate-biophysical-social system. The values of indigenous and non-indigenous communities are separate and unique, but collide when water resources are endangered. The unique and complex links between cultural and human values and the natural environment are strong but difficult to model in conventional modeling approaches. In order for each party to understand their role in the system, the system must be viewed holistically and collaborative a decision-making process that is considerate of both parties must be used.

Multi-criteria sensitivity analysis of the vulnerability of hydrologic systems to climate variability and change in the southwestern United States

PI: P.A. Ty Ferre, University of Arizona

With: Jesse Dickinson, Christopher Castro, Peter Troch, Stan Leake, Hoshin Gupta, Randy Hanson, Pamela Nagler, and Rafael Rosolem

The potential consequences of climate variability and climate change have been identified as major issues for the sustainability and availability of the water resources of the United States. Long-term decreases in precipitation will result in reduced recharge, lowered regional groundwater levels, loss of groundwater storage for communities, stream base flow depletion, and loss of riparian vegetation. We will examine how hydrologic systems filter climate signals and how this filtering depends on the frequency of the signal and the properties of the hydrologic system. An improved understanding of the vulnerability of hydrologic and riparian areas to future climate will inform water and riparian managers about which systems may be most sensitive to trends and periodic variations in climate.

Downscaled climate and hydrologic response for California and the Great Basin

PI: Lorraine Flint, USGS

With: Alan Flint, Michael Moran, John Dingman, James Thorne, Lisa Micheli, Healy Hamilton, Stuart Weiss, Bridget Thrasher, Claudia Tebaldi, Deanne PiPietro, Grant Ballard, and Sam Veloz

Climate change is causing rising temperatures and increased extremes in precipitation across the west. We've seen earlier snowmelt and longer droughts, impacting the ability of water supply managers to anticipate how to maintain our drinking water, agricultural water, and water for fisheries. These changes also affect the landscape, stressing vegetation, increasing forest fires, and challenging the survival of species, and are likely to become more pronounced. To adapt, natural resource managers need up-to-date, scientifically sound and accessible information.

This study will provide state-of-the-art climate and hydrology data for California and the Great Basin, and provide interpretations to guide the planning and decisions of natural resource managers. These analyses will help managers understand where in the region and on what landscapes effects of climate change are likely to be the most profound, how the environment is likely to change, and how certain the scientific community is about these changes. The results of this study will be available to managers and the public on a user-friendly website that explains the results and provides interactive data and maps. The website will provide answers to questions about climate change and the tools and science we use to explore how the earth is changing.

Trans-specific driver of climate-driven variation in forecasted distributional changes of Southwest birds and reptiles

PI: David Mattson, USGS

With: Matthew J. Johnson, Charles van Riper III, James R. Hatten, J. Tomas Giermakowski, Erika Nowak, Jennifer Homes, Michael Peter, and Paul Heinrich

Biodiversity and its indicators are declining worldwide in ways that are consistent with the predicted effects of climate change. Managers are faced with identifying where, when, and how to allocate their limited resources with maximal effect relative to emerging and evolving societal concerns. Forecasts can provide managers with the prospective identities and locations of species that are likely to be at future risk because of climate change.

Our research addresses three main questions of relevance to the use of species distribution models in forecasting the extent and locations of species' vulnerability to climate change: 1) What explains differences in forecasts of species distributions, and how do these explanations relate to species characteristics? 2) What are the relations our forecasts, based on species distribution models, to the results of assessments of species' vulnerability done using common vulnerability assessment methods? 3) What bird and reptile species, currently common or not of conservation concern, will be at risk with forecasted climate change in the southwestern U.S., and why?

Climate change vulnerabilities and adaptation strategies to wildfire in the southwestern United States

PI: Mark Schwartz, University of California – Davis

With: Mark Lubell, James Thorne, Patrick Gonzalez, Nate Stephenson, Max Moritz, Tim Brown, and Gregg Garfin

Climate change is driving stress in plant communities and stressed communities have differing, often negative, responses to wildfire. Forest wildfire is a growing problem in the southwestern US, with millions of dollars spent each year in fire control. We are identifying where and when forest and woodland ecosystems of the Southwestern US will become vulnerable to change as a consequence of fire. The Southwest has begun to lose forested ecosystems through fire and drought. This is likely to increase with increasing heat and drought. We assess where, and when, plant communities are projected to exhibit stress as a consequence of falling outside the bioclimatic window for that vegetation type. Stressed ecosystems are vulnerable to increased mortality and higher fire severity. Together, understanding fire probabilities and forest vulnerabilities will provide decision support for how fuels management (prescribed fire and mechanical fuels reduction) is deployed as well as appropriate management responses to wildfire events. An understanding of how vegetation is likely to change with climate will allow proactive land management decisions to guide forested ecosystems toward stable, functioning future states.

Effects of sea-level rise and extreme events on California coastal habitats

PI: John Takekawa, USGS

With: Rich Ambrose, Patrick Barnard, Michael Casazza, Susan De La Cruz, Glenn Guntenspergen, Alex Hall, Bruce Jaffe, Glen MacDonald, Cory Overton, Karen Thorne, Susan Ustin, Brian Collins, Kenneth Griggs, Eric Nelson, Steven Schwarzbach, and Andy Yuen

In California, the nearshore area where the ocean meets the land is a highly productive region that supports a wealth of wildlife, including several native bird species. The salt marshes, mudflats, and shallow bays of this boundary region are connected habitats critical to wildlife, local people, and communities. Climate change effects such as sea-level rise are altering these habitats, but we don't

know how they are being affected or will change in the future. This study will examine the links among these habitats and expected future changes at several sites along the California coast. It will review the current weather patterns, elevations, tidal range, and sediment of these connected habitats to see how they affect plants and animals, and to project how climate change may alter that balance. The goal of the project is to provide scientific information to support future planning and conservation of nearshore natural resources as climate changes.

RECOMMENDED FOR FUNDING IN 2013

Eight projects were recommended for funding in the 2013 proposal process. Work on these projects is expected to begin in October 2013.

Colorado River Basin streamflow projection under IPCC-CMIP5 scenarios: from the global to basin scale using an integrated dynamic modeling approach

PI: Christopher Castro, University of Arizona

Cooperators: Peter Troch (University of Arizona), Hsin-I Change (University of Arizona), James Prairie (Bureau of Reclamation), Jon Skindlov (Salt River Project), and Chuck Collum (Central Arizona Project)

Multicriteria sensitivity analysis of the vulnerability of hydrologic systems to climate variability and change in the southwestern U.S. (continuation from 2012)

PI: Jesse Dickinson, USGS – Arizona Water Science Center

Natural climate variability in the changing climate: how interannual, decadal, and century timescales affect daily weather patterns

PI: Alexander Gershunov, Scripps Institution of Oceanography

Co-PI: Dan Cayan, Scripps Institution of Oceanography

Cooperators: Suraj Polade (Scripps Institution of Oceanography), Noah Knowles (USGS), Rupa Basu (California Environmental Protection Agency), and Deanna Dullen (National Park Service)

Linking climatic, hydrological, and ecological changes at intermediate timescales in a Great Basin Watershed

PI: Alexandra Lutz, Desert Research Institute

Evaluating the impact of climate science produced in the Southwest Climate Science Center on resource management agency decisions

PI: Alison Meadow, University of Arizona

Co-PI: Tamara Wall, Desert Research Institute

Preliminary assessment of the landscape of climate relevant resource management decisions in the southwest

PI: Mark Schwartz, University of California, Davis

Cooperators: Christine Albano (University of California, Davis), Gwen Arnold (University of California, Davis), Eric Fleishman (University of California, Davis), Mark Lubell (University of California, Davis), Richard Ambrose (University of California, Los Angeles), Dan Cayan (Scripps Institution of Oceanography), Britta Daudert (Desert Research Institute), Michael Dettinger (Scripps Institution of Oceanography), Alexander Gershunov (Scripps Institution of Oceanography), Glen MacDonald (University of California, Los Angeles), Alison Meadow (University of Arizona), Jonathan Ovepeck (University of Arizona), Kelly Redmond (Desert Research Institute), and Brad Udall (University of Colorado)

Downscaling climate change models to local site conditions: effects of sea-level rise and extreme events to California coastal habitats (continuation from 2012)

PI: John Takekawa, USGS – Western Ecological Research Center

Influence of interannual North Pacific Jet variability on Sierra Nevada Fire regimes

PI: Valerie Trouet, University of Arizona

Co-PI: Julio Betancourt (USGS)

LIZ URBAN

Principals' and Affiliates' Activities

In addition to research directly funded by the SW CSC, the principal investigators and other research affiliates have been engaged in a range of activities that further both the scientific and collaborative goals of the SW CSC including a number of peer-reviewed publications, speaking at national and regional conferences, and engaging with our stakeholders and the general public at meetings and workshops throughout the Southwest.

PEER-REVIEWED PUBLICATIONS

Ault T.R., J.E. Cole, **J.T. Overpeck**, G.T. Pederson, S. St George, B. Otto-Bliesner, C.A. Woodhouse, C. Deser. (in press). "The continuum of drought variability in western North America: insights from instrumental, paleoclimate and global climate model data." Journal of Climate.

Bernstein, E. J., **C. M. Albano**, T. D. Sisk, T. E. Crews and S. Rosenstock (2013). "Establishing Cool-Season Grasses on a Degraded Arid Rangeland of the Colorado Plateau." Restoration Ecology.

Blois, J. L., J. W. Williams, M. C. Fitzpatrick, **S. T. Jackson** and S. Ferrier (2013). "Space can substitute for time in predicting climate-change effects on biodiversity." Proceedings of the National Academy of Sciences 110(23): 9374-9379.

Brusca, R.C., J. Wiens, W.M. Meyer, J. Eble, K. Franklin, **J.T. Overpeck** and W. Moore (in press). "Dramatic Response to Climate Change in the Southwest: Robert Whittaker's 1963 Arizona Mountain Plant Transect Revisited." Global Change Biology.

Cayan, D. R., S. Moser, G. Franco, M. Hanemann and M. Jones, Eds. (2013). California Climate Scenarios Assessment, Springer.

Das, T., E.P. Maurer, D.W. Pierce, **M.D. Dettinger, D.R. Cayan** (2013). "Increases in Flood Magnitudes in California Under Warming Climates." Journal of Hydrology 501.

Dettinger, M. (2013). "Projections and downscaling of 21st century temperatures, precipitation, radiative fluxes and winds for the Southwestern US, with focus on Lake Tahoe." Climatic Change 116(1): 17-33.

Jackson, S. T. (2013). "Natural, potential and actual vegetation in North America." Journal of Vegetation Science 24(4): 772-776.

Maurer, E. P., T. Das and **D. R. Cayan** (2013). "Errors in climate model daily precipitation and temperature output: time invariance and implications for bias correction." Hydrology and Earth System Sciences Discussions 17: 2147-2159.

Neiman, P. J., F. M. Ralph, B. J. Moore, M. Highes, K. M. Mahoney and **M. D. Dettinger** (2013). "The landfall and inland penetration of a flood-producting atmospheric river in Arizona Part One: Observed synopotic-scale and hydrometeorological characteristics." Journal of Hydrometeorology 14(2): 460-484.

Pierce, D. W. and **D. R. Cayan** (2012). "The Uneven Response of Different Snow Measures to Human-Induced Climate Warming." Journal of Climate 26(12): 4148-4167.

Polade, S. D., A. Gershunov, D. R. Cayan, M. D. Dettinger and D. W. Pierce (2013). "Natural climate variability and teleconnections to precipitation over the Pacific-North American region in CMIP3 and CMIP5 models." Geophysical Research Letters 40(10): 2296-2301.

Weiss, J.L., J.L. Betancourt, **J.T. Overpeck** (2012). "Climatic limits on foliar phenology during major droughts in the Southwestern U.S.A." Journal of Geophysical Research. 117.

NON-PEER-REVIEWED PUBLICATIONS

Dettinger, M. D. and L. Ingram (2013). The coming megafloods. Scientific American. 308: 74-71.

Also published as Dettinger & Ingram, 2013, Nadchodzą megapowodzie: Swiat Nauki (Polish edition of Scientific American), February 2013; próximas grandes inundações do norte: Scientific American Brasil, February 2013; Mega-alluvioni in arrivo: Le Scinze (Italian edition), March 2013; Die Nachste Sinfflut: Spektrum der Wissenschaft (German edition), April 2013, 74-81; Steam flow results in a river flood flowing through the sky: Nikkei Science (Japanese edition), April 2013.

REPORTS

Lackstrom, K., A. Brennan, D. Ferguson, M. Crimmins, L. Darby, K. Dow, K. Ingram, **A. Meadow**, H. Reges, M. Shafer, and K. Smith. 2013. The Missing Piece: Drought Impacts Monitoring. Available online at www.swcsc.arizona.edu/announcements/missing-piece-drought-impacts-monitoring

CONFERENCE PRESENTATIONS

Principal investigators or other affiliates of the SW CSC presented at 14 different conferences this year. The conferences ranged from national meetings such as the American Meteorological Society annual convention and the Native American Fish and Wildlife Society Annual Meeting to smaller, regional conferences focused on the specific needs of resource managers and other decision makers in a particular area. Examples of regional meetings include the Great Basin Climate Forums, organized by the Great Basin Landscape Conservation Cooperative; the California Water Group annual meeting; and the Southwest Climate Summit, organized by the Southwest Climate Science Center. A list of conference presentations follows.

Cayan, Dan (with **Daniel Walton** and Alex Hall) "A Combined Dynamical/Statistical Technique for Regionalizing an Ensemble of Climate Change Signals." American Meteorological Society Annual Convention. Austin, TX, January 2013.

Dettinger, Michael D. "Water-related climate change projections for California's urban supplies" California Water Group Annual Meeting: Urban Water Institute. San Diego, CA. August 2012.

Dettinger, Michael D, and Schladow, G., "Atmospheric rivers and the Lake Tahoe system." MTNCLIM Workshop. Estes Park, CO. October 2012.

Dettinger, Michael D "Storms, floods and atmospheric rivers in the changing Southwest." Southwest Climate Summit. Tucson, AZ. June 2012.

Fleishman, Erica. "The impact of climate change on natural ecosystems." Southwest Climate Summit. Tucson, AZ. June 2012.

Fleishman, Erica "Discriminating among ecological responses to weather and climate" Great Basin Climate Forum. Reno, NV. October 2012.

Fleishman, Erica "Natural ecosystems and tribal issues." Webinar hosted by the Southwest Climate Assessment. December 2012

Jackson, Stephen "Influence of cross-scale interactions in forest response to climate change: past and future." Symposium on Forest regeneration and climate change; 4th International Ecosummit. Columbus, OH. October 2012.

Jackson, Stephen Panelist, "Climate change and natural resources." Native American Fish and Wildlife Society annual meeting. Fort McDowell, AZ. May 2013.

Jackson, Stephen Keynote Speaker, "Climate Change and the Adirondacks: Looking Forward From the Past." Adirondack Research Council 20th Annual Conference. Lake Placid, NY. May 2013.

Meadow, Alison Panelist, "Climate change and natural resources: An introduction to the Southwest Climate Science Center." Native American Fish and Wildlife Society annual meeting. Fort McDowell, Arizona. May 2013.

Polade, Suraj "Natural modes of variability and their teleconnections over the Pacific-North American region in CMIP3 and CMIP5 models." American Geophysical Union Fall Meeting. San Francisco, CA. December 2012

Redmond, Kelly T, J Steenburgh, K. Kunkel, N. Doesken, R. Gillies, J Horel, M. Hoerling, T. Painter. "The weather and climate of the Southwest." Southwest Climate Summit. Tucson AZ. June 2012.

Redmond, Kelly T. "Great Basin weather and climate: Summer recap, current status, winter prospects." Great Basin Climate Forum. Reno NV. October 2012.

Redmond, Kelly T. "Great Basin weather and climate: Summer recap, current status, winter prospects." Northern Great Basin Climate Forum: Winter Outlook. Oregon Institute of Technology, Klamath Falls OR. November 2012.

Redmond, Kelly T. "What is climate change? How is it manifested in the western U.S.?" Climate Change Science for Effective Resource Management and Public Policy in the Western United States, EPSCoR Western Tri-State Consortium. Las Vegas NV. March 2013.

Jackson, Steve T., A. Meadow, J. Leenhouts, D. Cayan, E. Fleishman, A. Gershunov, G.M. MacDonald, J.T. Overpeck, K. Redmond (presenter), M.W. Schwartz, B. Udall. "The Southwest Climate Science Center: Developing best practices at the science / management interface." 11th Climate Prediction and Applications Science Workshop. Logan UT. April 2013.

Redmond, Kelly T, B. Daudert. "Climate information access for UDSI Climate Science Centers and Landscape Conservation Cooperatives." 11th Climate Prediction and Applications Science Workshop. Logan UT. April 2013.

Redmond, Kelly T. "Great Basin weather and climate: Winter recap, current status, summer prospects." Great Basin Climate Forum. Northern Nevada Science Center, Desert Research Institute. May 2013.

WORKSHOPS

The Southwest Climate Science Center was represented by principal investigators and affiliates at a number of workshops throughout the region.

The *Great Basin Climate Forums* are hosted by The California Nevada Applications Program (CNAP), Great Basin Landscape Conservation Cooperative (GBLCC) and the Western Regional Climate Center (WRCC). The goal of the forums is to summarize the current climate conditions in the Great Basin and discuss how those conditions affect resources in the Great Basin. The forum topics revolved around on-going drought conditions in the Great Basin with in-depth presentations. Topics covered included:

- **Nevada drought response and coordination efforts**
- **Fire behavior and climate in the Great Basin**
- **Overview of current climate and hydrology prospects**
- **Drought effects on horse and burro populations in Nevada**

Christine Albano attended on behalf of the SW CSC and **Kelly Redmond** has been a presenter at all of the forums.

The *National Climate Assessment Town Hall* meeting in La Jolla, CA in January 2013 was a day-long meeting that brought together approximately 90 people, including climate experts and users of climate information from academia, local, state, tribal, and federal governments, non-profit organizations, businesses, and industry. Participants had the opportunity to:

- **learn about the National Climate Assessment and the process leading to the 2013 National Climate Assessment Report**
- **talk with report authors, members of the National Climate Assessment and Development Advisory Committee, and National Climate Assessment staff about how the information provided in National Climate Assessment products is and can be used in various decision making contexts;**
- **learn about local and regional efforts to respond to the impacts of climate change in the Southwest U.S.; and**
- **collaborate with other meeting participants to identify ways that communities can participate in the long-term National Climate Assessment process.**

Michael Dettinger participated in the Town Hall as an author of the National Climate Assessment.

Stephen Jackson participated in the *National Academy of Sciences, Committee on Understanding and Monitoring Abrupt Climate Change* in January 2013 and gave a presentation entitled "Some ecological and paleoecological perspectives on abrupt change – climatic and otherwise."

Hydrologic Extremes in a Warming World: California Perspectives Workshop was held in La Jolla, CA in October 2012. The purpose of the workshop was to identify applied science activities that can facilitate climate change adaptation to extreme events and severe weather and to develop a road map for implementing those activities. The focus was on flood management and California. **Dan Cayan** organized the workshop; **Michael Dettinger** and **Dan Cayan** participated in the workshop; and **Alison Meadow** attended as a representative of the SW CSC.

A two-day workshop entitled *Drought Impacts Monitoring: The Missing Piece* was held Tucson, AZ in March 2013. The purpose of the workshop was to identify the challenges of integrating drought

impacts monitoring into more conventional drought monitoring protocols as well as identify tools for overcoming those challenges. The workshop was led by Carolinas Integrated Sciences and Assessment (CISA) and the Climate Assessment for the Southwest (CLIMAS) – both NOAA-RISA programs and, therefore, was also an example of CSC-RISA collaboration. **Alison Meadow** participated on behalf of the SW CSC.

COMMUNICATIONS AND OUTREACH

In addition to the workshops and conferences listed above, SW CSC Principals have been actively engaging with regional stakeholders and the general public. Some highlights include:

Christine Albano is a member of the California LCC science-manager team.

Albano also presented to emergency response planners in the Lake Tahoe-Reno area about the social and ecological impacts of extreme winter storm events in the Lake Take region at the first *ARkStorm: Impacts at Lake Tahoe* meeting in April 2013.

Mike Dettinger spoke at a number of meetings, including a public seminar entitled "Preparing for Climate Change—What Nevadans should know," at Western Nevada College as part of the college's Earth Day activities.

Dettinger also spoke to the Southern California Tribal Consortium about climate change in the San Diego region in February 2013.

Dan Cayan and **Glen MacDonald** were panelists at the public event *Climate Change in the Tucson Region: Findings of the Southwest Climate Assessment* in Tucson, AZ in May 2013. This was a public event that drew an audience from around Tucson and was covered by the local press:

LIVE.AZSTARNET.COM/EVENT/LIVE_BLOG_ON_SOUTHWEST_CLIMATE_ASSESSMENT?PAGE=0 WWW.UANEWS.ORG/BLOG/NEW-BOOK-OUTLINES-UNIQUE-CHALLENGES-CLIMATE-INSTABILITY-POSES-SOUTHWEST

SOUTHWEST CLIMATE ASSESSMENT

The Southwest Climate Assessment is a contribution to the 2013 National Climate Assessment. The assessment provides a summary and synthesis of the past, present, and projected future of the region's climate, emphasizing new information and understandings since publication of the previous national assessment in 2009. Investigators in the Southwest Climate Science Center were instrumental in the development of the Southwest Climate Assessment, acting as authors on eight of 20 chapters and facilitating its creation in their role as the Southwest Climate Alliance. Below is a list of chapters authored by SW CSC PIs and affiliates.

Overpeck, J., G. Garfin, A. Jardine, D. E. Busch, **D. Cayan, M. Dettinger, E. Fleishman, A. Gershunov, G. MacDonald, K. T. Redmond**, W. R. Travis, and **B. Udall**. 2013. "Summary for Decision Makers, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 1–20. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Steenburgh, W. J., **K. T. Redmond**, K. E. Kunkel, N. Doesken, R. R. Gillies, J. D. Horel, M. P. Hoerling, and T. H. Painter. 2013. "Present Weather and Climate: Average Conditions." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 56–73. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Hoerling, M. P., **M. Dettinger**, K. Wolter, J. Lukas, J. Eischeid, R. Nemani, B. Liebmann, and K. E. Kunkel. 2013. "Present Weather and Climate: Evolving Conditions." In Assessment of Climate Change in the

Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 74–100. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Cayan, D., M. Tyree, K. E. Kunkel, C. Castro, **A. Gershunov**, J. Barsugli, A. J. Ray, **J. Overpeck**, M. Anderson, J. Russell, B. Rajagopalan, I. Rangwala, and P. Duffy. 2013. "Future Climate: Projected Average." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 101–125. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Gershunov, A., B. Rajagopalan, **J. Overpeck**, **K. Guirguis**, **D. Cayan**, M. Hughes, **M. Dettinger**, C. Castro, R. E. Schwartz, M. Anderson, A. J. Ray, J. Barsugli, T. Cavazos, and M. Alexander. 2013. "Future Climate: Projected Extremes." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 126–147. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Fleishman, E., J. Belnap, N. Cobb, C. A. F. Enquist, K. Ford, **G. MacDonald**, M. Pellant, T. Schoennagel, L. M. Schmit, **M. Schwartz**, S. van Drunick, A. L. Westerling, A. Keyser, and R. Lucas. 2013. "Natural Ecosystems." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 148–167. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Udall, B. 2013. "Water: Impacts, Risks, and Adaptation." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 197–217. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Brown, H. E., A. C. Comrie, D. M. Drechsler, C. M. Barker, R. Basu, T. Brown, **A. Gershunov**, A. M. Kilpatrick, W. K. Reisen, and D. M. Ruddell. 2013. "Human Health." In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 312–339. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

THE FULL TEXT OF ASSESSMENT OF CLIMATE CHANGE IN THE SOUTHWEST UNITED STATES CAN BE FOUND AT: **SWCARR.ARIZONA.EDU**

NATIONAL CLIMATE ASSESSMENT

Georgakakos, A.P., Fleming, P., **Dettinger, M.**, Peters-Lidard, C., Reckow, K., Richmond, T.C., White, K., and Yates, D. Water resources, Chapter 3 in 2013 National Climate Assessment: US Global Change Research Program report to Congress, 25 p.


BRIAN KLUG

Professional Development

The SW CSC funded several graduate students and a postdoctoral associate this year either through the core agreement with the host universities or through competitive research grants.

Neil Berg and **Daniel Walton**, both from UCLA's Atmospheric and Oceanic Sciences department, have been working with Alex Hall on the "Climate Change in the Los Angeles Region" project.

Berg graduated with a BS in Atmospheric and Oceanic Sciences from the University of Wisconsin in 2009 and began his PhD program in the same field at UCLA in the fall of 2009. As part of his SW CSC-funded research, he developed a way to downscale global climate model projections of precipitation to the regional scale over Los Angeles. His PhD dissertation focuses on climate change impacts to the hydrological cycle over Southern California. Berg expects to graduate in December 2014 and will pursue a career in either a private or a public policy institution that focuses on climate change prediction and understanding.

Walton has just completed his fourth year in UCLA's Atmospheric and Oceanic Sciences Ph.D. program. His research interests involve regional climate modeling, especially dynamical and statistical downscaling in coastal regions. He developed a hybrid dynamical/statistical technique that allows for approximate dynamical downscaling of an entire ensemble. This powerful technique makes it quick and easy to compute temperature change projections for many GCMs. This technique was used to downscale GCMs from both the CMIP3 and CMIP5 archives. His most recent research has involved comparing dynamical and statistical downscaling techniques over Southern California and investigating projections of temperature change (2041-2060 minus 1981-2000) from three different methods: two statistical (Bias Correction with Constructed Analogs (BCCA) and Bias Correction and Spatial Disaggregation (BCSD)) and one dynamical downscaling using a regional model (WRF). Walton expects to graduate in December 2014 and would like to pursue a career in academia.

Amber Wright is a postdoctoral researcher at University of California, Davis, working with Mark Schwartz on the project "Climate Change and its Impact on Ecological and Social Systems in the Southwest." She is using ecological niche models to predict how California's reptiles and amphibians will respond to climate change. Wright was the lead author on the report to the California Department of Fish and Game that resulted from this project.

Wright received her B.S. in Biological Sciences from Cornell University, an M.A. in Conservation Biology from Columbia University, and a Ph.D. in Population Biology from the University of California, Davis. Prior to her work with the SW CSC she was a Science and Technology Policy fellow in the California State Senate through the California Council on Science and Technology. She will be starting a faculty position in the Department of Biology at the University of Hawaii, Manoa in January 2014.

Kristin Guirguis is a postdoctoral scholar whose work with Alexander Gershonov at Scripps Institution of Oceanography has been partially funded through a SW CSC research award. She has been actively conducting research focused on temperature extremes and human health impacts. This work includes an analysis of heat waves in a nonstationary framework that looks at heat waves relative to changing climate conditions, which is important from a human health perspective. She also developed a new database of recent heat waves defined from their health impact, which is described in a new journal article[2]. This information was presented to the National Weather Service where state and county level public health and emergency managers attended and was instrumental in initiating a connection/collaboration with stakeholders interested in improving health outcomes during heat waves.

Guirguis interacts regularly with the Managing Warning Coordination Meteorologist at the NWS and with the California Environmental Protection Agency on issues related to better health outcomes, vulnerable populations, and improved heat warnings. She also serves on a Vulnerable Populations working group to develop an updated public outreach document on climate change impacts for San Diego.

Guirguis contributed research to Chapter 7 of the Southwest Climate Assessment Report (see page 19) and a "state of knowledge" paper on weather extremes in the U.S., which provided technical input for the National Climate Assessment[3].

Suraj Polade is a postdoctoral scholar at Scripps Institution of Oceanography who is fully funded by the SW CSC. Polade authored a recent paper on natural climate variability and teleconnections to precipitation over the Pacific-North American region (see page 14). He also presented his findings at the American Geophysical Union annual meeting in December 2012.

Christine Albano, a research associate at University of California, Davis, has actively engaged with several key stakeholders in our region. She is a member of the California LCC science-manager team, attends the Great Basin Climate Forums, and presented to emergency management planners in the Lake Tahoe region about extreme events. She also co-authored a paper on the state of rangeland on the Colorado Plateau (see page 13) and co-authored, along with PhD fellows from the Northwest and Pacific Islands CSCs, a paper entitled "Potential effects of warming climate on visitor use in three Alaskan national parks," which is in press at Park Science. Christine attended the Northwest CSC Climate Bootcamp in August 2012 on behalf of the SW CSC (her report is in the SW CSC 2012 annual report).

Britta Daudert is an assistant research scientist at the Desert Research Institute. Her recent focus has been on developing web interfaces that allow resource managers to quickly and efficiently access climate change and weather information relevant to their management and planning efforts. To this end, she has been investigating the topics of web usability and user testing procedures as well as elements of web design and user/machine interactions. She collaborated with Kelly Redmond to present on her work at the Climate Predication and Applications Science Workshop in April 2013.[4]

2 **Guirguis, K.**, A. Gershunov, A. Tardy, and R. Basu, (in review). "The Impact of Recent Heat Waves on Human Health in California." Journal of Applied Meteorology and Climatology.

3 Peterson, T. C., R. R. Heim, R. Hirsch, D. P. Kaiser, H. Brooks, N. S. Diffenbaugh, R. M. Dole, J. P. Giovannettone, **K. Guirguis**, T. R. Karl, R. W. Katz, K. Kunkel, D. Lettenmaier, G. J. McCabe, C. J. Paciorek, K. R. Ryberg, S. Schubert, V. B. S. Silva, B.

4 C. Stewart, A. V. Vecchia, G. Villarini, R. S. Vose, J. Walsh, M. Wehner, D. Wolock, K. Wolter, C. A. Woodhouse and D. Wuebbles (2013). "Monitoring and Understanding Changes in Heat Waves, Cold Waves, Floods, and Droughts in the United States: State of Knowledge." Bulletin of the American Meteorological Society **94**(6): 821-834.

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